

Nickel-Hydrogen (NiH₂) Common Pressure Vessel (CPV) Cell Capacity Loss and Voltage Collapse

During an investigation of anomalous voltages during a NASA scientific mission, a NASA Engineering and Safety Center (NESC) team discovered that the design of NiH₂ CPV batteries may be susceptible to a unique electrolyte bridging between the two internal cells resulting in undesired ionic current flow. This condition can lead to depletion of the capacity within one of the two cells.

Applicability

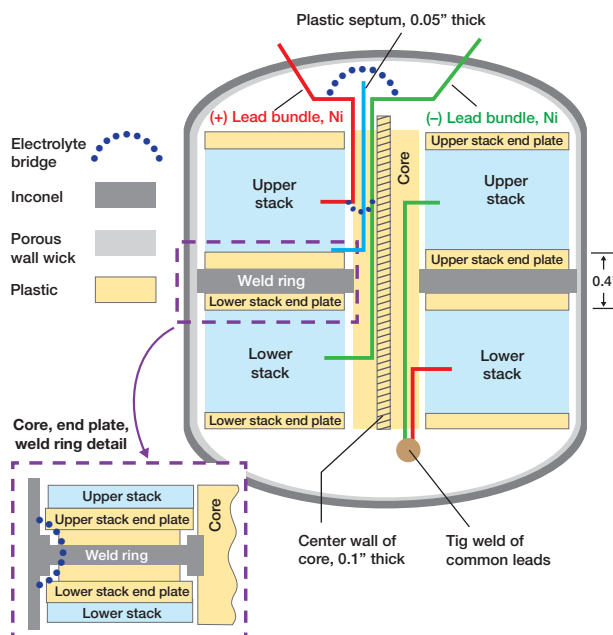
All NiH₂ battery applications utilizing CPVs.

Background

The Wilkinson Microwave Anisotropy Probe (WMAP) was launched in 2001 and outfitted with an 11 cell CPV NiH₂ battery. WMAP was designed to operate in full sun conditions. An unexpected series of discrete voltage drops began in August 2009 that were clearly traceable to the loss of one of the two individual cells contained within multiple battery CPVs. An examination of the limited telemetry available provided confirmation that each event was associated with a transient thermal load increase that occurred in conjunction with each step loss of voltage. Battery differential voltage telemetry indicated the events were apparently occurring randomly throughout the battery with no evidence that both cells within any given CPV were being affected. An NESC team was quickly assembled to evaluate the conditions and provide recommendations to arrest or reverse the degradation characteristics in order to complete the scheduled extended mission.

Potential NiH₂ Battery CPV Issue

As a result of the investigation into the anomalous battery behavior, analysis and testing determined NiH₂ CPV battery cell designs are susceptible to a unique electrolyte bridging between the two internal cells that can potentially result in undesired ionic current flow, which can ultimately deplete the capacity within one of the two cells. The internal design configuration of a normal CPV allows free material transport between cells as both cells within a CPV are intended to share the hydrogen gas necessary for NiH₂ cell functionality. Two conditions were identified where it is possible for free potassium hydroxide (KOH) electrolyte to creep between the cell stacks and to establish an undesirable conductive ionic pathway that effectively shorts out one of the two cells within the CPV. Those conditions are: 1) activating the NiH₂ CPV cells with excess electrolyte present or 2) allowing the cells to reach very low states of charge during operation. Based on observations and available data, once the electrolyte bridge is established there are no effective means to eliminate the problem with the possible exception of fully reconditioning the battery cell, or at least extended operation (up to a few weeks) in an open circuit condition. The application of periodic high



Simple Illustration of Ni-H₂ Common Pressure Vessel Design and Identified Possible Electrolyte Bridging Locations

rate charge pulses (between C/10 and C/4) was observed to be effective in at least temporarily stemming the continued voltage degradation of the WMAP battery and in a similar laboratory test battery. However, careful consideration to avoid high temperatures (above +10°C) needed to be in place to reduce the possibility of thermal runaway.

References

Wilkinson Microwave Anisotropy Probe (WMAP) Battery Operations Problem Resolution Team (PRT), NESC Document Number: RP-10-00608, NASA TM Number: TM-2010-216840

Effects of a Simulated Electrolyte Bridge in a Common Pressure Vessel (CPV) Nickel Hydrogen Cell, Aerospace Report Number: ATR-2010 (5175)-1

For information contact the NESC at www.nesc.nasa.gov